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FRESH-WATER MUSSEL SHELLS

(Excerpts from Research Series No. 9, entitled "Fresh-Water Mussel Shells, the Basis For an Arkansas Industry", by W. Paul Brann, Bureau of Research, University of Arkansas, Fayetteville, Arkansas.)

The use of mussel shells as industrial raw material is of recent origin. The shell, or mother-of-pearl of the mollusk, was formerly considered as waste material, for the principal interest was in valuable pearls which might be found within the shell. In 1856, when Tiffany and Company paid $2,500 for a single pearl discovered in New Jersey, considerable excitement arose and, as a result, a search for pearls was made in all streams in the eastern part of the United States and in the Mississippi River basin. Mussel shells were opened and discarded after a thorough examination for pearls.

Although fresh-water shells had been utilized in button manufacturing in Europe since about 1840, it was not until around 1891 that industrial use of this shell for buttons was made in the United States. According to the United States Census of Manufactures for 1900, J. F. Boepple, a German immigrant, is credited with having established the first fresh-water shell button plant in the United States, located at Muscatine, Iowa, where the Unio, or niggerhead shells, were found abundantly along the Mississippi River. The success of this first company, although based upon the crude manufacturing tools and processes utilized in Austria and Germany, soon led to widespread use of shells for button manufacturing, and plants were established along the Mississippi River from Red Wing, Minnesota, to Louisiana, Missouri. Muscatine remained the center of the industry by virtue of ample raw material and because it was the home of Mr. Boepple, who was a directing influence in the development of the industry. Today it is estimated that the button industry at Muscatine manufactures approximately 95 per cent of all buttons made from river shells. Although the raw material around Muscatine has been almost exhausted, this center of industry has extended its procurement of raw material to cover all the important mussel-bearing rivers in the Mississippi River basin.

Over the past 15 years Arkansas has taken the lead in the production of shells for the button industry. According to the United States Fish and Wildlife Service, Arkansas has been supplying from about 13 to 35 per cent of all shells used by the total industry.

In the case of individual firms located at Muscatine, Iowa, this percentage is much higher, for it is estimated by some manufacturers that approximately 50 to 75 per cent of the raw material finished into buttons at their particular plants is obtained from Arkansas streams.

TABLE 1. PRODUCTION OF FRESH-WATER MUSSEL SHELLS, BY STATES, 1929-44

Year	Arkansas	Illinois	Indiana	Iowa	Kentucky	Michigan	Tennessee	Wisconsin	Other States	Total
	Tons	Tons	Tons	Tons	Tons	Tons	Tons	Tons	Tons	Tons
1929	5,435	2,174	2,174	2,174	-----	2,718	5,707	1,902	4,892	27,176
1930	9,221	4,164	2,677	1,785	-----	2,380	3,867	-----	5,651	29,745
1932	2,047	3,139	3,003	819	546	955	1,501	137	1,501	13,648
1933	6,934	3,316	4,824	1,507	1,809	2,713	4,220	1,507	3,316	30,146
1934	5,440	4,946	3,462	989	1,484	1,484	2,967	989	2,967	24,728
1935	1,866	1,442	933	424	509	594	1,442	169	1,102	8,481
1936	10,235	4,094	3,509	1,170	2,047	877	3,509	877	2,924	29,242
1937	7,558	3,509	2,699	540	3,239	540	5,669	540	2,699	26,993
1938	1,671	1,488	1,321	503	972	156	2,235	172	743	9,261
1939	2,447	1,336	1,309	306	2,050	142	3,299	372	1,953	13,214
1940	1,656	745	1,407	414	1,821	-----	1,076	-----	1,159	8,278
1941	3,302	1,391	1,391	695	4,345	-----	5,388	174	695	17,381
1942	4,598	1,379	1,150	460	7,127	-----	7,357	230	690	22,991
1943	1,855	428	714	285	4,424	-----	6,136	143	285	14,270
1944	3,654	812	2,030	406	5,075	-----	7,105	-----	1,218	20,300
Total	67,919	34,363	32,603	12,477	35,448	12,559	61,478	7,212	31,795	295,854

Source: U. S. Fish and Wildlife Service.

The relative importance of shell-producing states to the total production is shown in Table 1. Arkansas, Illinois, Indiana, and Tennessee have been historically, the most important sources of this raw material. Over a long period of time, however, there has been a continuous shift in the relative importance of different states as shell producers. As streams become exhausted, as the size of shells limited the economic feasibility of working certain beds, and as states restricted the working of certain rivers or sections of rivers by law, some producing areas became relatively unimportant while production increased in other areas. In the course of time, a reverse condition may exist when streams that have produced few shells may become extremely important.

The commercial fresh-water shells, which have been fished over the past 50 years for use in button manufacturing, are described by the industry according to natural characteristics to include the niggerhead, pimpleback, monkey-face, three-ridge, pig-toe, washboard, mucket, pocketbook, and black and yellow sand shells. For the most part the total production of shells from Arkansas streams in recent years has been made up of the following types and proportions:

Type of shell	Production in Arkansas Per cent
Sand shells	17.2
Niggerhead shells	22.3
Mixed shells	60.5
All shells	100.0

There is a great deal of variation in quality between the different species of shell. Some shells are adaptable for one use while others may be used for entirely different purposes. Even within the same species there is considerable variation regarding such factors of quality as color, luster, texture, shape, and thickness. For commercial purposes it is desirable to have shells of considerable luster and pearliness and of a firm texture yet not too hard, but which are not colored by spotting or stains, or which do not contain a pink, salmon, or purple nacre.

Methods of Fishing. There are three principal methods of obtaining shells from the river.

(1) The crowfoot method, the most common, is fairly inexpensive and is well adapted to all sorts of conditions. The necessary equipment for this method includes an iron bar, 12 to 20 feet long, to which is attached lines about 3 feet long and spaced from 4 to 6 inches apart. Pronged wire hooks are attached at intervals to these lines. By means of a tow line, the bar is lowered almost to the bottom of the stream. Then the run is made over the shell bed by dragging the wire hooks in a direction parallel to the current. The mussels lie half imbedded at the bottom of the stream with the hinder end of the shell partially open and extending against the current. As the crowfoot hook passes over and is inserted into the shell opening, the mussel closes tightly upon it and is thus drawn from the water. Using this method of shelling, the operator obtains from about 200 to 800 pounds of shells per day. However, there are certain disadvantages in the use of this method, the most important of which is the possible injury to mussels, especially the young ones, which may close onto the hooks and then drop off before being raised out of the water, or else are taken from the

hook by the operator because of size limitation and thrown back into the water. The Fairport Biological Station at Fairport, Iowa, has found that approximately 38 per cent of all mussels that are returned to the water after having been obtained by the crowfoot method may subsequently die.

(2) The second method, known as hogging shells, is considered to be the most simple and least expensive. A flashlight and a sack is all the equipment necessary. The process involves merely wading into shallow water at night and picking shells out of the water as the mussels come up for feeding. This method permits the operator to obtain from about 25 to 100 pounds of shells per night.

(3) The third method, the diving method, is considered to be the most efficient yet the most expensive because the necessary equipment includes a barge, motor, and an air compressor. The operator, equipped with a diving helmet, is lowered into the water to an average depth of about 25 feet. An air line, about 50 feet long, permits the operator to move about in order to collect shells and place them in a sack, which, in turn, is raised to the barge.

Other methods include the use of such equipment as the dip-net drag, shoulder rake, and shell tongs. The dip-net drag is useful in deep water where there is no current and is suitable in rivers and lakes with soft-mud bottoms. It is a simple and inexpensive method, for all the equipment that is necessary is a wire hoop covered with a net and attached to a pole 16 to 20 feet long. The net is used to scoop the mussel shells from the beds. The shoulder rake is essentially a metal rake having 10 to 12 curved tines. The rake with a wire hoop is fastened to a handle and is operated the same way as the dip-net drag. This equipment is very useful in swift water where the bottom is not too hard and where there are no obstructions. The shell tongs consist of two rakes on ends of long handles and are worked like a pair of scissors. They are lowered into the water and closed over the shells.

Preparation of Shells for Market. Once the shells have been removed from the beds and transported by boat or barge to some concentration point along the river, they are placed into a metal vat containing a small amount of water, covered by a sack, and are then subjected to a cooking process for about 20 minutes. The mussels are killed by steam, enabling the shells to be opened easily. After cooking, the shells are put on a sorting table where each shell is handled separately to examine the meat for pearls and slugs. For the most part, shell meats are considered as waste material, although they are sometimes dried and made into a meal which may be fed to fish or mixed with grain for poultry feed. Any pearls that are discovered are sold on the commercial market. The mussel shells, freed from meat, are ready for the market.

Prices Received for Shells. Although about 60 per cent of the shells marketed in Arkansas during 1945 were classified as mixed shells, the sand shells and niggerheads are considered to be of greater value. The prices paid for such shells are as follows:

Type of shell	Average price per ton, 1930-40	Average wartime price per ton
Mixed shells.....	$30	$ 70
Niggerhead shells.....	40	120
Sand shells.....	70	175

Shell prices, which influence the volume of production, may vary considerably between communities and in different seasons of the year. The basic prices are determined by competitive bidding among several buyers in each market, with premiums being paid for superior quality. Indirectly, the price for shells reflects the market for buttons. In recent years, increased shell prices have indicated a favorable wartime button market.

Before the establishment of button-blank cutting plants near centers of production, all locally produced shells were shipped directly to button finishers for processing into finished buttons. Today, however, the practice is for button manufacturers to locate button-blank cutting plants near the source of raw material, and to transport the rough blanks instead of bulky shells to their manufacturing plants for finishing into buttons.

Processing Steps

Sorting and Classifying. After the mussel shells have been delivered and concentrated at the cutting plant, they are sorted by hand according to type, such as sand shell, washboard, and niggerhead, to quality, and to size. The shells are then stock-piled in covered or exposed bins, although if they are not protected from the weather they will soon lose luster and become chalky. Since it is the practice of most button-blank cutting plants to buy enough shells from June to October (the harvesting season) to permit a full year's operation, the proper care of these shells in stock piles is very important.

Before the shells are prepared for use in the cutting plant, they are classified according to size and character. This is done by a mechanical grader, which is essentially a long revolving drum made up of sections with openings of different sizes. As the shells pass through this drum they are sorted, and then stock-piled, according to size. The classified shells may be better adapted to particular grades of buttons, to uniform speeds of machinery, and they enable the processor to determine the size of button that may be cut with a minimum of waste.

Soaking. The first step in processing is to place the shells from which the blanks are to be cut into large metal tanks or barrels filled with water where they remain for 2 to 3 weeks. This soaking softens the material, making it possible to saw the blanks without chipping them.

Blank-cutting. Cutting button blanks is a mechanical process, but the volume obtained, quality, and economy depend largely upon the skill and judgment of the individual operating the machine.

The button-cutting machine is essentially a lathe. It is fitted with a tubular saw of a diameter to obtain the desired size of button blank, and with a wooden plug and ratchet handle with which the shell is forced against the rotating saw. The shell is held with special tongs or mitten against the wooden plug, and is advanced toward the revolving saw by means of a feed plunger or screw operated by the ratchet handle. Throughout the process a small stream of water is applied to the cutting saw and shell, in order to prevent the heating of the saw and to clean the shell dust from the saw teeth. After the blanks are cut, they pass into a hopper and then fall into a bucket.

Size of button blanks is determined by the diameter of the cutting end of the saw. Therefore, for buttons of various sizes it is necessary to have saws of different diameters. The unit of button measure is 1/40 inch and is called a line. Buttons from fresh-water shells may vary in size from 14 to 40 lines or from one-third to one inch in diameter. The most common sizes of blanks cut in Arkansas plants are 17, 20, 22, 24, 30, and 36 lines. Blanks of different sizes are obtained from the same shell.

On the average, mixed shells are cut into button blanks at the rate of 15 per cent of the original weight, niggerheads at the rate of 20 per cent, and sand shells at the rate of 40 per cent. For the most part, however, the number of pounds of shell necessary to produce a gross of button blanks will vary according to the line, character of shell, skill of the button cutter, and the judgment of the plant manager. Although it is important to utilize as much of the raw material as possible in cutting the shells, the market for buttons of a particular size is a more important factor in determining the pattern of utilizing shells than is efficient use. In either respect it is the skill of the cutting machine operator and the plant manager which reconciles efficiency with market prospects in order to achieve the profitable use of raw material in button-blank manufacturing.

Production of Novelty Materials

Considerable use is made of shells as raw material for novelty products. For the most part, novelty blanks are made in the same plants engaged in cutting button blanks. The sand shell is particularly adaptable for novelties. In former years this shell was shipped largely to France for processing into products requiring mother-of-pearl inlay.

Waste Material

A considerable amount of waste occurs in the manufacture of button blanks. After the blanks have been cut and material for novelty obtained, the remainder of the shell has been discarded as waste. Assuming that mixed shells cut into blanks at a rate of 15 per cent of the original weight, niggerheads at 20 per cent, and sand shells at 40 per cent, it is estimated that if the total production of about 4,075 tons of shells purchased by button-cutting plants in Arkansas during 1945 had been cut into button blanks, the volume of waste material would have been about 3,400 tons or approximately 7 million pounds.

Although mussel-shell waste may be used for poultry feed and lime, very little use has been made of this waste material. For the most part the waste shells are given away or sold to individuals and towns for use on driveways and for street improvements. The economic feasibility of utilizing waste shell from button-blank cutting plants depends largely upon the ability to concentrate sufficient volume.

The Manufacture of Finished Buttons

The manufacture of button blanks into finished buttons is almost wholly mechanized, requiring considerable investment in plant and equipment. The scope of mechanization may be understood by a description of the actual processing steps.

Processing Steps in Finishing Buttons

Semifinishing. After the button blanks are received at the finishing plant they undergo four semifinishing processes. These include: (1) Classifying, which is a machine operation designed to separate the button blanks according to thickness. (2) Tumbling, a machine operation which involves placing button blanks into watertight tumbling barrels where they are churned in a mixture of water and an abrasive in order to remove the bark or back side of the shell as well as any marks left by the saw teeth of the blank cutting machine. (3) Grinding, a machine operation to obtain uniform thickness. The grinding machine is equipped with two conveyor belts on which button blanks move under two revolving grinding wheels, 4 inches wide by 18 inches in diameter. The only hand labor required in this operation is for pouring the blanks into the machine hopper and seeing that the bark or back side of the blank is turned upward as it moves along the belt. This machine is equipped with discharge pipes for removing dust and grit. (4) Soaking, which involves placing the semifinished buttons in water in order that they might be softened for the final finishing process.

Complete Finishing. The complete finishing of buttons is obtained by use of the automatic facing and drilling machine. This is the most intricate machine operation in button manufacturing and the machine itself has revolutionized the button industry. The operation of this machine has been described by Dr. Robert E. Coker of the United States Bureau of Fisheries as follows:

The blanks are fed by hand into depressions in the tops of vertical chucks, which are arranged in series constituting an endless chain. As the chucks in endless chain pass around the circumference of the machine each blank is automatically operated upon by various tools, and each tool is automatically sharpened and prepared for the succeeding blank. The processes accomplished in the machine consist in rounding the edges and carving out the center in the desired pattern to make the face of the button and in drilling two or four holes according to pattern. After the first hole the drill rises, the button makes a turn through a fourth or a half of one revolution (according to whether it is to be a four-hole or two-hole button), when the drill again descends to make a new hole. After the last hole is drilled the chuck opens automatically to release the button, which is sucked into a tube connected with the blower system to be dropped into a bucket through a counting tube.

Some twenty-odd distinct operations are combined in the double automatic machine, and it is interesting to record them. Let it be noted that the button travels in an oblong orbit, while the carving tools and the drills, respectively, travel in smaller circular orbits at opposite ends of the button orbit.

The traveling chuck, which is open after releasing a finished button, closes on the new blank placed in the top depression.

The chuck with the blank begins to revolve rapidly on its axis while continuing to travel to the right.

The face of the revolving and traveling button is applied to a carving tool of proper form to make the desired face. The tool itself is stationary on its axis, but travels in orbit with the buttons.

The facing completed, the tool rises.

The rotation of the blank is stopped.

The tool, continuing on its orbit, is sharpened on an emery wheel.

Before meeting another blank the tool is lowered by a small fraction of an inch to compensate for the shortening due to the grinding on the emery wheel.

The chuck, with its blank, leaves the orbit of the carving tool at a tangent to pass over to the orbit of the drilling tools.

When the blank is in just the right position, one of the drills descends to make the first hole in the blank. In this operation the drill revolves, while the blank is stationary on its axis, but both travel together.

The drill rises.

The chuck, with blank, turns through one-fourth of a revolution.

The drill descends for the second hole.

The drill rises.

The blank turns another fourth of a revolution.

Third hole is drilled.

Drill rises.

Blank turns.

Fourth hole is drilled.

Drill rises.

Drill continues in its shorter circular orbit, to return into proper position for a later blank.

Button chuck rises a little and releases the button.

As the chuck passes beneath a suction tube the button is drawn up against a small, fine screen in the tube.

The button drops of its own weight upon a small trap.

When a number of buttons corresponding to a given weight have accumulated on the trap it releases and drops the buttons into a bucket.

The tripping of the door or trap registers the number of buttons finished.

Tumbling and Polishing. In order to smooth off the rough edge and to make the buttons ready for receiving the final polish they are placed into tumbling barrels. Following this process they are placed in the polishing machine where they are given a polished luster by means of sulphuric acid and steam.

Drying. The buttons are next dried in a centrifugal dryer. If colors are to be added the buttons are then ready for dying.

Sorting. The final step in preparing buttons for market is sorting according to quality and grade. Buttons are handled individually by skilled workers who separate the buttons into a variable number of grades according to freedom from defects, and with respect to such quality factors as color, luster, and iridescence.

Carding. The sorted buttons are then ready for carding and packing. Buttons sold in bulk are packaged.

Cost of Processing

It is difficult to determine the cost of processing shells into buttons because of the great variation in grade and quality of shells, differences in size of buttons, quality of labor, size and output of plant, and type of management. However, by courtesy of two button manufacturers, the relative cost of processing raw material into buttons of three different sizes is presented in Table 2. This table represents processing costs only, and does not include sales expense and a margin for profit. According to these figures the cost of the shell raw material plus the cost of cutting shells into blanks, overhead expenses in cutting, and freight charges on blanks from Arkansas to Muscatine account for 75 per cent of the total cost in processing a gross of 17-line buttons, 79 per cent for 20-line buttons, and 80 per cent for 24-line buttons.

An estimate of capital investment required to establish a button-finishing plant is presented below through courtesy of the Barry Company, manufacturers of button equipment, Muscatine, Iowa. The number and type of machines required are based on the use of one automatic facing and drilling machine. Leaders in the button industry believe that a plant of minimum size for manufacturing buttons should contain at least 10 automatic facing and drilling machines; therefore, the number of pieces of equipment listed below and the net price should be multiplied by 10 in order to determine the total equipment investment. On this basis the necessary equipment would cost over $61,000.

Number	Type of machine	Net price*
7	Cutting machines symbol "S1"	$525.00
1	Centrifugal dryer	300.00
1	Double blank grinder	1,125.00
1	Classifying machine	578.00
1	Automatic facing and drilling machine	2,500.00
1	Tumbling barrel	148.68
1	Polishing machine	260.00
1	Button conveying and sorting table	495.00
4	Fluorescent lights for same	45.00
1	Cutting machine bench for eight machines complete	187.00
	Total equipment cost	$6,163.68

* As of April, 1946.

TABLE 2. RELATIVE COSTS FOR MANUFACTURING BUTTONS, PER GROSS, ACCORDING TO THE SEVERAL STEPS IN PROCESSING

Items of cost	17-line button	20-line button	24-line button 1/
	Cents	Cents	Cents
Shell	15	18	23
Cutting	22	26	32
Overhead expense in cutting	11	13	16
Grinding	1	1	1.5
Overhead expense in grinding	1.5	1.5	1.5
Blank sorting	1	1	1
Overhead expense in blank sorting	1	1	1
Machining	2.5	2.5	3
Overhead expense in machining	3.5	3.5	4.5
Sorting	2	2	2
Overhead expense in sorting	3	3	3
Total (allowance for losses in process of manufacturing not included)	63.5	72.5	88.5
	Per cent	Per cent	Per cent
Ratio of shell cost to total	23.6	24.8	26.0

1/ Better grade of raw material used as compared to that used for 17- and 20-line buttons in these cost estimates.

Marketing of Buttons

The volume of buttons produced from fresh-water mussel shells has been declining since 1929. Fresh-water pearl buttons are faced with competition from buttons made of ocean pearl and plastics. The ocean pearl is an expensive button, the fresh-water pearl is a medium-priced button, and the plastic button is of the cheapest type. Therefore, fresh-water pearl buttons must meet market competition from both ocean pearl and plastic industries. It is only in the medium-priced field that fresh-water pearls are able to maintain an established market. During the war fresh-water pearl buttons competed easily with the ocean pearl due to the limited supply of the latter. Also, fresh-water pearl buttons made from thin shells of low quality were able to compete fairly successfully with plastic buttons. In the interest of maintaining a well-rounded market, however, there seems to be a definite trend for manufacturers of fresh-water shell buttons to expand their operations to include the use of ocean pearl and plastic materials, thereby producing for all three types of markets in the same plant or under the same management. To a limited extent the same equipment is adaptable to all three types of raw material.

The present output of fresh-water pearl buttons by the industry in Iowa comprises about 85 per cent plain pearl buttons and 15 per cent fancy pearl buttons. About 65 per cent of this total output is of the two-hole type of button and 35 per cent the four-hole type.

Buttons are sold in bulk form or as carded buttons. About 85 per cent of the present output is sold in bulk and 15 per cent as carded. About 60 per cent of the carded buttons produced by the industry are sold to chain stores, while 40 per cent go to wholesale dry goods companies.

The sale of buttons in bulk, according to type of market, is distributed as follows:

Type of market	Button purchases in bulk
	Per cent
Clothing manufacturers (including manufacturers of shirts, underwear, house dresses, and aprons).....	90
Laundries.....	5
Button jobbers.....	5
Total.....	100

Reliable sources in the button industry are generally agreed that the market for fresh-water pearl buttons, particularly carded fancy buttons, will be favorable during the next 10 years.

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